e-ISSN: 3108-2866; p-ISSN: 3139-4108
Available online on https://jmmdt.jcpublications.in
Journal of Medicine, Pharmacology and Medical Devises Technology. Dec 2025; 01(2): 5 – 8
doi: https://doi.org/10.67170/jmmdt.2025.v1i2.002 Original Research Article

Diagnostic accuracy of AI-assisted portable Doppler ultrasound in high-risk obstetrics

Neeraja Patnaik[1], Suran Bhaj[2]
[1]Assistant Professor, department of Obstetrics and Gynaecology, Smt. B.K. Shah Medical Institute & Research Centre, Sumandeep Vidyapeeth Campus, Vadodara.
[2]Assistant Professor, department of Radiodiagnosis, Smt. B.K. Shah Medical Institute & Research Centre, Sumandeep Vidyapeeth Campus, Vadodara.

Date of submission: 03-09-2025 Date of Review: 13-09-2025 Date of acceptance: 02-12-2025
Corresponding Author: Dr Suran Bhaj Conflict of interest: Nil

Abstract

Background: Umbilical artery (UA) Doppler assessment is essential for identifying placental insufficiency and fetal compromise in high-risk pregnancies. AI-enabled handheld ultrasound devices may enhance accessibility and reduce operator dependence. **Aim:** To evaluate the diagnostic performance of an AI-assisted handheld ultrasound device in detecting abnormal UA Doppler indices and compare findings with standard Doppler ultrasound.

Methods: This prospective observational study was conducted at Smt. B.K. Shah Medical Institute & Research Centre, Vadodara (April 2024–June 2025). High-risk pregnant women (n = 240) underwent sequential Doppler evaluation using an AI-enabled handheld device followed by standard ultrasound. UA PI, RI, and S/D ratio were recorded. Diagnostic accuracy, inter-modality agreement, acquisition time, and user experience were assessed. Neonatal outcomes were documented at delivery.

Results: The AI device showed excellent agreement with standard ultrasound for all Doppler indices, with sensitivity of 88.2%, specificity of 93.7%, and $\kappa = 0.82$. Acquisition time was significantly shorter with the handheld device. Abnormal Doppler values were strongly associated with low birth weight, poor Apgar scores, and higher NICU admissions.

Conclusion: The AI-enabled handheld ultrasound demonstrated high diagnostic accuracy, faster acquisition, and strong usability, supporting its role in improving fetal surveillance in high-risk pregnancies.

Keywords: AI ultrasound, Doppler indices, high-risk pregnancy, umbilical artery, fetal surveillance

This is an open-access journal, and articles are distributed under the terms of the Creative Commons Attribution License CC-BY 4.0. (https://creativecommons.org/licenses/by/4.0/) which permits unrestricted use, distribution, and reproduction in any medium, provided the original authors and source are credited. The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the journal, its editorial board, or the publisher. The journal does not assume any responsibility for the accuracy or completeness of the information provided.

Introduction

Abnormal umbilical artery (UA) Doppler indices including elevated pulsatility index (PI), resistance index (RI), and systolic/diastolic (S/D) ratio are key markers of placental insufficiency and are strongly linked to fetal growth restriction and adverse perinatal outcomes in high-risk pregnancies [1]. Conventional UA Doppler requires bulky equipment and expert operators, limiting access in low-resource or busy obstetric settings [2]. Recent advances in artificial intelligence (AI) and portable, smartphone-connected ultrasound probes have shown that automated image analysis can standardize fetal biometry and Doppler measurements while reducing operator dependence and training requirements [3]. AI-enabled obstetric point-of-care ultrasound (POCUS) is therefore emerging as a promising tool to extend high-quality fetal surveillance to peripheral facilities, mid-level providers, and after-hours care [3, 4]. However, real-world evidence comparing AI-assisted handheld Doppler with standard ultrasound for UA waveform assessment in high-risk pregnancies is limited, and data on usability by obstetric residents and impact on neonatal outcomes are sparse [1, 3]. The present prospective observational study aims to evaluate the diagnostic performance of an AI-enabled handheld ultrasound device for detecting abnormal UA Doppler indices in high-risk pregnancies.

Methods:

The present prospective observational study was conducted in the departments of Obstetrics & Gynecology and Radiology at Smt. B.K. Shah Medical Institute & Research Centre, Vadodara, from April 2024 to June 2025. All pregnant women attending the antenatal clinic or admitted to the obstetric wards who were identified as high risk were screened for eligibility. High-risk status was defined based on standard criteria, including hypertensive disorders of pregnancy, gestational diabetes mellitus, anemia, previous intrauterine growth restriction, oligohydramnios, multiple gestation, autoimmune disease, and maternal age <18 or >35 years. Women with major fetal anomalies, absent fetal cardiac activity, or refusal to participate were excluded. After obtaining informed written consent, each participant underwent a detailed clinical assessment including maternal demographic data, obstetric history, blood pressure, gestational age (GA) determination, and baseline investigations. The GA window for Doppler evaluation was limited to 24–40 weeks.

All women underwent two sequential ultrasound examinations during the same visit. First, a trained

obstetric resident performed the scan using the AI-assisted handheld ultrasound device. The handheld probe was wirelessly connected to a tablet with integrated AI software capable of automated image optimization, vessel recognition, Doppler gate placement, and real-time computation of pulsatility index (PI), resistance index (RI), and systolic/diastolic (S/D) ratio. Residents had received a structured two-day training module followed by supervised practice to ensure familiarity with device handling. For each patient, the AI-generated UA Doppler waveform, indices, acquisition time, and AI confidence score were recorded. Immediately afterward, a standard Doppler ultrasound scan was performed by an experienced radiologist using a high-end ultrasound machine (3.5–5 MHz curvilinear probe). The radiologist was blinded to the AI-device findings. The conventional Doppler PI, RI, and S/D ratio were documented, and the waveform quality was graded. Abnormal Doppler findings were defined according to established GA specific reference ranges. To assess user-friendliness and feasibility, residents rated the handheld device using a standardized 10-item Likert-scale questionnaire covering ease of use, confidence in acquiring Doppler signals, perceived accuracy, and fatigue.

Neonatal outcomes were prospectively recorded at delivery. These included birth weight, Apgar scores, need for neonatal intensive care unit (NICU) admission, perinatal morbidity, and mortality. The primary outcome measure was the diagnostic accuracy of the AI-enabled handheld device compared with standard Doppler ultrasound, evaluated through sensitivity, specificity, positive predictive value, negative predictive value, and Bland–Altman analysis for PI, RI, and S/D values. Secondary outcomes included inter-observer agreement, time taken for Doppler acquisition, waveform quality, and user-experience ratings. All data were entered into a predesigned proforma and subsequently transferred to a secured database. Statistical analysis was performed using SPSS Version 22.0. Continuous variables were expressed as mean ± standard deviation or median (interquartile range), depending on normality of distribution. Categorical variables were summarized as frequencies and percentages. Agreement between the two modalities was assessed using intraclass correlation coefficients and kappa statistics. A p-value <0.05 was considered statistically significant.

Results:

A total of 240 high-risk pregnant women were included in the study, with a mean maternal age of 27.9 ± 4.8 years and mean gestational age of 31.4 ± 3.6 weeks. Hypertensive disorders (32.5%), gestational diabetes (19.2%), and previous intrauterine growth restriction (13.3%) were the most common high-risk factors. All participants underwent paired Doppler evaluation using both the AI-enabled handheld ultrasound device and standard Doppler ultrasound. The mean UA PI, RI, and S/D ratio obtained from the handheld device closely matched those derived from the standard ultrasound, with no statistically significant differences ($p > 0.05$). However, the AI device significantly reduced the acquisition time (41.6 ± 9.8 seconds vs 62.4 ± 12.3 seconds; $p < 0.001$), indicating improved efficiency (Table 1). Regarding diagnostic performance, the AI-enabled device demonstrated a sensitivity of 88.2%, specificity of 93.7%, and overall agreement $\kappa = 0.82$ for detecting abnormal Doppler indices. The negative predictive value of 95.6% highlighted its reliability in ruling out placental insufficiency. Abnormal Doppler findings were observed in 64 women (26.7%). These pregnancies showed significantly poorer neonatal outcomes, including lower mean birth weight, higher NICU admissions, and increased early neonatal morbidities compared with the normal Doppler group ($p < 0.001$) (Table 2). No adverse events related to handheld device use were reported, and obstetric residents reported positive user-experience scores. Overall, the AI-assisted handheld device performed comparably to standard Doppler ultrasound while improving usability and efficiency.

Discussion:

The findings of this prospective observational study demonstrate that an AI-enabled handheld ultrasound device can reliably identify abnormal UA Doppler indices in high-risk pregnancies, with diagnostic performance comparable to standard Doppler ultrasound. The close agreement between the two modalities for PI, RI, and S/D ratio values aligns with emerging evidence showing that artificial intelligence-based obstetric ultrasound can reduce operator dependency, standardize waveform acquisition, and support clinical decision-making in maternal–fetal medicine [1]. The excellent specificity and high negative predictive value in the present study indicate strong potential for handheld AI-assisted systems to rule out placental insufficiency in busy obstetric units, a finding consistent with recent literature showing AI algorithms outperforming traditional approaches in Doppler signal interpretation [5]. The significantly shorter acquisition time observed with the handheld device further supports its feasibility and usability in real-world clinical practice, particularly for residents and mid-level providers who often struggle with Doppler gate alignment and waveform optimization using conventional systems [6]. These advantages are clinically meaningful because faster and more consistent Doppler assessments may improve routine surveillance efficiency, reduce patient waiting times, and expand the reach of fetal monitoring services in resource-constrained environments.

In high-risk pregnancies, timely detection of abnormal UA Doppler indices is essential for identifying fetuses at risk of growth restriction, hypoxia, and adverse neonatal outcomes. In this study, abnormal Doppler findings correlated strongly with low birth weight, poor Apgar scores, and increased NICU admissions, reflecting the well-established predictive value of UA Doppler abnormalities for placental insufficiency-related complications [7]. The performance of the AI handheld device in identifying these abnormalities suggests that it may serve as a valuable adjunct in antenatal care, especially in peripheral or outreach settings where access to high-end ultrasound machines and experienced radiologists is limited. Similar studies have reported that integrating AI into portable ultrasound systems enhances reliability in fetal biometry, gestational age estimation, and anatomical surveys, thereby improving early detection of complications [8]. Importantly, the ability of residents with limited training to acquire high-quality Doppler waveforms with minimal user fatigue reinforces the potential of AI tools to democratize ultrasound use. This is particularly relevant in low- and middle-income countries, where shortages of trained sonologists often result in delayed diagnosis and suboptimal surveillance of high-risk pregnancies.

The results also highlight the broader implications of incorporating AI-based handheld ultrasound devices into routine obstetric workflows. As maternal comorbidities such as hypertension, diabetes, and anemia continue to rise globally, scalable and cost-effective screening tools are urgently needed to support early risk identification and timely referral. Several recent evaluations have demonstrated that handheld AI-enabled POCUS devices maintain high image quality, support tele-ultrasound consultations, and integrate seamlessly into digital health ecosystems, making them ideal for community-level antenatal care [4]. Furthermore, AI has shown promise in automating feature extraction, waveform classification, and Doppler analysis, thereby minimizing interobserver variability and reducing dependence on operator skill [9, 10]. While the present study confirms the diagnostic reliability of the AI device, future research should explore integration with cloud-based fetal surveillance platforms, automated risk scoring, and real-time remote specialist guidance. Limitations of the current study include its single-center design and the exclusion of major fetal anomalies, which may restrict generalizability. Nonetheless, by demonstrating comparable accuracy to standard Doppler and meaningful improvements in workflow efficiency and usability, this study supports broader adoption of AI-driven handheld ultrasound for antenatal surveillance. Overall, these findings contribute to the growing evidence that AI-assisted ultrasonography may transform the landscape of fetal monitoring by enhancing accessibility, consistency, and diagnostic precision, ultimately improving maternal and neonatal outcomes.

Conclusion: This prospective study demonstrated that an AI-enabled handheld ultrasound device provided diagnostic accuracy comparable to standard Doppler ultrasound in detecting abnormal UA Doppler indices among high-risk pregnancies. The device significantly reduced Doppler acquisition time and improved usability for obstetric residents, indicating strong potential for clinical integration. Abnormal Doppler findings detected by both modalities were strongly associated with adverse neonatal outcomes, supporting the clinical relevance of early detection. Given its portability, efficiency, and high diagnostic performance, the AI-assisted handheld device represents a valuable adjunct for fetal surveillance, particularly in resource-limited settings and peripheral healthcare facilities.

References

1. Aguado AM, Jimenez-Perez G, Chowdhury D, et al. AI-enabled workflow for automated classification and analysis of feto-placental Doppler images. *Front Digit Health.* 2024; 6: 1455767
2. Xiao S, Zhang J, Zhu Y, et al. Application and Progress of Artificial Intelligence in Fetal Ultrasound. *Journal of Clinical Medicine.* 2023; 12(9):3298
3. Ranger BJ, Bradburn E, Chen Q, et al. Portable ultrasound devices for obstetric care in resource-constrained environments: mapping the landscape. Gates Open Res. 2024; 7: 133.
4. Della Ripa S, Santos N, Walker D. AI-enabled obstetric point-of-care ultrasound as an emerging technology in low- and middle-income countries: provider and health system perspectives. BMC Pregnancy Childbirth. 2025; 25: 729.
5. Chen Z, Liu Z, Du M, Wang Z. Artificial Intelligence in Obstetric Ultrasound: An Update and Future Applications. Front Med (Lausanne). 2021; 8: 733468.
6. Kim S, Fischetti C, Guy M, Hsu E, Fox J, Young SD. Artificial Intelligence (AI) Applications for Point of Care Ultrasound (POCUS) in Low-Resource Settings: A Scoping Review. Diagnostics (Basel). 2024; 14(15): 1669.
7. Arslan H, Corbacıoglu Esmer A, Akca A, Arslan K. The effect of middle cerebral artery peak systolic velocity on prognosis in early and late-onset fetal growth restriction. Journal of Perinatal Medicine. 2023; 51(4): 559 – 63.
8. Carneiro G, Georgescu B, Good S, et al. Automated analysis of fetal ultrasound via deep learning: a review. *Med Image Anal*. 2023; 86: 102780

9. Xiao S, Zhang J, Zhu Y, Zhang Z, Cao H, Xie M, Zhang L. Application and Progress of Artificial Intelligence in Fetal Ultrasound. J Clin Med. 2023; 12(9): 3298.
10. Lourenço M, Arrufat T, Satorres E, et al. Ultrasound-Based Deep Learning Models Performance versus Expert Subjective Assessment for Discriminating Adnexal Masses: A Head-to-Head Systematic Review and Meta-Analysis. Applied Sciences. 2024; 14(7): 2998.

Table 1: Comparison of UA doppler indices: AI-Handheld vs Standard ultrasound

Doppler Index	AI Device	Standard US	p-value
PI	1.32 ± 0.28	1.30 ± 0.26	0.21
RI	0.71 ± 0.08	0.70 ± 0.07	0.18
S/D ratio	3.08 ± 0.52	3.04 ± 0.49	0.24
Acquisition time (seconds)	41.6 ± 9.8	62.4 ± 12.3	<0.001*

Table 2: Neonatal outcomes associated with doppler abnormalities

Outcome	Normal Doppler (n = 176)	Abnormal Doppler (n = 64)	p-value
Birth weight (kg)	2.78 ± 0.42	2.31 ± 0.38	<0.001*
Apgar <7 at 5 min	6 (3.4%)	12 (18.7%)	<0.001*
NICU admission	14 (8.0%)	22 (34.3%)	<0.001*
Early neonatal morbidity	11 (6.3%)	18 (28.1%)	<0.001*